



A new species of rainfrog of the genus *Diasporus* (Anura: Eleutherodactylidae) from Serranía de Tabasará, Panama

ABEL BATISTA^{1,2,3,4}, MARCOS PONCE¹ & ANDREAS HERTZ^{2,3}

¹Universidad Autónoma de Chiriquí, David, Panama

²Senckenberg Forschungsinstitut und Naturmuseum Frankfurt, Senckenberganlage 25, 60325 Frankfurt a. M., Germany

³Johann Wolfgang Goethe-University, Institute for Ecology, Evolution & Diversity, BioCampus-Westend, Siesmayerstr. 70, 60323 Frankfurt am Main, Germany

⁴Corresponding author. abelbatista@hotmail.com

Abstract

A new frog species of the genus *Diasporus* is described from Llano Tugrú, Corregimiento de Peña Blanca, Distrito de Müna, Comarca Ngöbe-Buglé, Serranía de Tabasará, west-central Panama, around 1700 m a.s.l. The new species differs from all other members of the genus by a combination of morphological characters, in particular, its large size, its dorsal skin texture and its bright coloration. This species is the largest species in the genus *Diasporus*; it is an inhabitant of cloud forest, living among mosses and bromeliads. All specimens were found between the understory ($\approx 1\text{--}2$ m) and the mid-canopy ($\approx 2\text{--}10$ m). The call of this species consists of single, short notes that are reminiscent of a “whistle” and range from 2.0 to 2.7 kHz. Herein we present, besides morphological data used to describe the new species, the description of the male mating call, a distribution map, and brief ecological notes.

Key words: *Diasporus igneus* sp. nov., advertisement call, natural history, Comarca Ngöbe Buglé, cloud forest

Resumen

Una nueva especie de rana del género *Diasporus* es descrita de Llano Tugrú, Corregimiento de Peña Blanca, Distrito de Müna, Comarca Ngöbe-Buglé, Serranía de Tabasará, centro occidental de Panamá, alrededor de 1700 m.s.n.m. La nueva especie difiere de todos los otros miembros del género por una combinación de caracteres morfológicos, en particular, su gran tamaño, la textura de su piel dorsal y su brillante coloración. Esta especie es la más grande del género *Diasporus*; es un habitante del bosque nuboso, viviendo entre musgos y bromelias. Todos los especímenes fueron encontrados entre el sotobosque ($\approx 1\text{--}2$ m) y el estrato medio del bosque ($\approx 2\text{--}10$ m). El canto de esta especie consiste en una nota corta parecida a la de un “silbido que varía entre 2.0 y 2.7 kHz. Aquí presentamos, junto con los datos morfológicos usados por la descripción de la nueva especie, la descripción del canto nupcial del macho, un mapa de distribución y notas breves de su ecología.

Palabras claves: *Diasporus* sp. nov., canto nupcial, historia natural, Comarca Ngöbe Buglé, bosque nuboso

Introduction

Panama is home to 199 species of amphibians (Jaramillo *et al.* 2010). Auth (1994) listed 172 for the country, which means that 27 additional species have been found or described from the country in a relatively short period (Jaramillo *et al.* 2010; Köhler 2011; see also Frost 2011). Nonetheless, the knowledge of Panamanian amphibian diversity is still fragmentary and substantial research remains to be done to produce a fuller picture.

The west-central Panamanian highlands are dominated by the Serranía del Tabasará (Fig. 1). Most of this area is occupied by indigenous people of the ethnic groups *Ngöbe* and *Buglé*, who inhabit villages from the lowlands to elevations below 1100 m.a.s.l. At higher elevations, the landscape has been transformed into crop and cattle-ranching areas. Throughout the ridge at the continental divide, the vegetation is almost undisturbed. The Serranía de Tabasará has only been surveyed recently for its herpetofauna, which has rendered remarkable results, including

the discovery of numerous new taxa and new records of rare species of amphibians and reptiles (Köhler *et al.* 2007; 2008; Lotzkat *et al.* 2010; Hertz *et al.* 2011). Despite its importance as an area of endemism, the Serranía de Tabasará remains unprotected and is endangered due to advancing deforestation (Myers & Duellman 1982; Savage *et al.* 2004; Köhler *et al.* 2007).

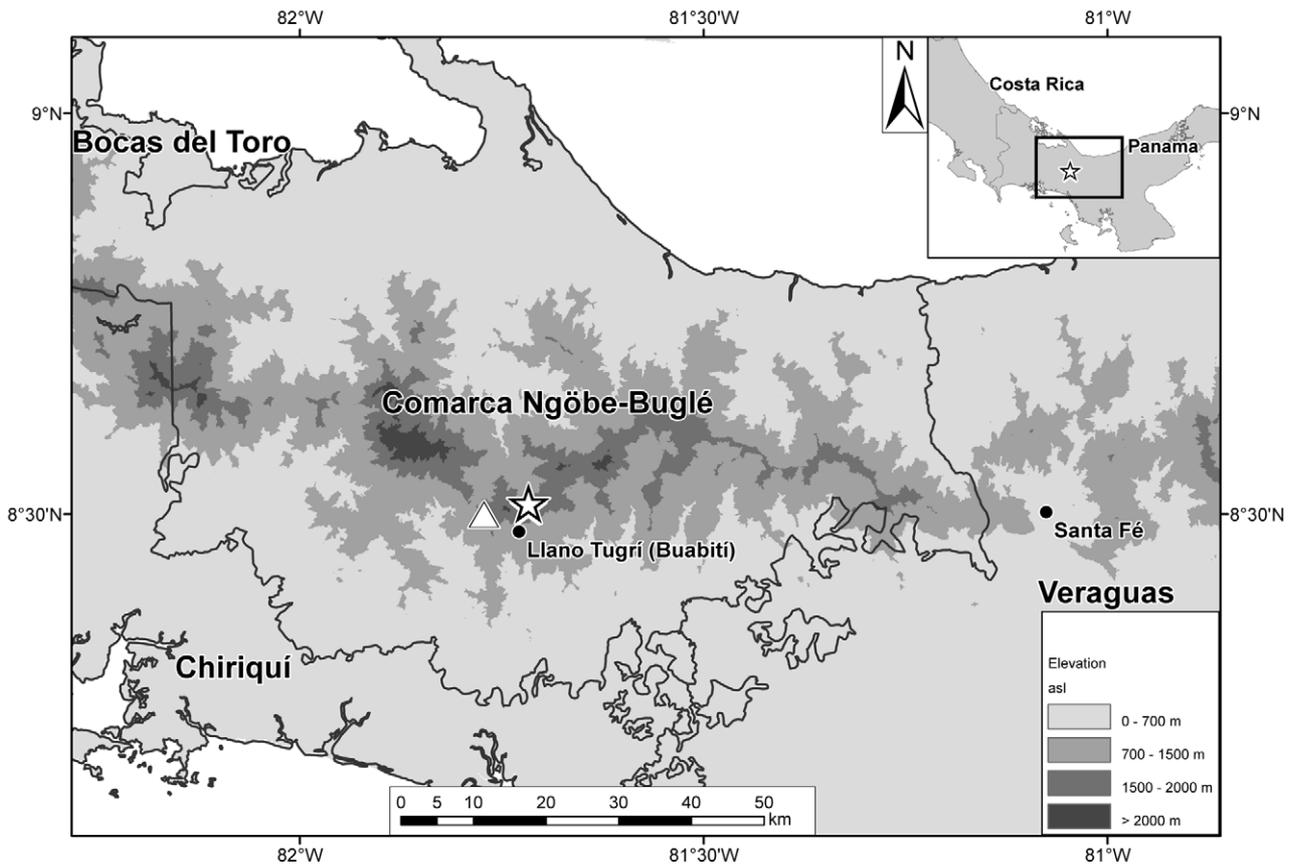


FIGURE 1. Map showing the collection sites for *Diasporus igneus*. Llano Tugrí (a star) and La Nevera (a triangle).

The genus *Diasporus* comprises small frogs with short limbs and expanded disk pads with or without lanceolate or papillate tips, that inhabit rainforests from northeastern Ecuador to Honduras. Adult males possess well-developed vocal slits and a single external subgular vocal sac. Their characteristic “dink-dink-dink” call, which can be more like a “whistle” in some species, is commonly heard in lower Central America. Calling males sit at sites from ground level to several meters up on plants (Savage 2002). During a recent survey in the Serranía de Tabasará, we found several specimens assignable to the genus *Diasporus* (*sensu* Hedges *et al.* 2008) that represent a new species that is described herein. We assign the new species to the genus *Diasporus* on the basis of several morphological characters present in other members of the genus (presence of entire oval palmar tubercles, expanded finger and toe disks, males having two longitudinal gular folds), and because this frog emits a call that coincides in structure with the characteristic call of other members of *Diasporus*.

Material and methods

Field work was carried out in the Serranía de Tabasará near Llano Tugrí, Corregimiento de Peña Blanca, Distrito de Müna, Comarca Ngöbe-Buglé and La Nevera, south-western slope of Cerro Santiago, Serranía de Tabasará, Comarca Ngöbe Buglé, Distrito de Nole Duima, Corregimiento de Jadeberi, Panama, during March, April, and November 2009 (Fig. 1). The collecting area is part of a cloud forest with a predominant vegetation of trees, covered by epiphytes and mosses (Fig. 2). We sampled an altitudinal range between 1530 and 1720 m a.s.l. at Llano Tugrí and between 1600 and 1700 m a.s.l. at La Nevera. The specimens mentioned in this paper were collected during opportunistic searches at night.

Specimens were sacrificed with a euthanasia solution (T61), fixed with formalin (10%) and ethanol (94%), and stored in alcohol (70%). For future genetic research, a fresh liver sample of the holotype has been stored in the tis-

sue sample collection of the MHCH (Museo Herpetológico de Chiriquí) and the left arm of the paratype SMF 89821 in the tissue collection of the SMF (Senckenberg Museum of Frankfurt). Morphological nomenclature, measurements, and diagnosis usually follow the methodology of Duellman & Lehr (2009) and Köhler (2011). For the description of the unguis flap we follow Lynch (2001) and Savage (2002). All measurements were made using digital calipers and were rounded to the nearest 0.1 mm. Measurements with mean standard deviation and range in parenthesis.



FIGURE 2. Habitat of *Diasporus igneus* at La Nevera (1700 m a.s.l), southwestern slope of Cerro Santiago, Serranía de Tabasará, Comarca Ngöbe Buglé, Distrito de Nole Duima, Corregimiento de Jadeberi, Panama.

The following morphometrical measurements were taken (with abbreviations indicated): length from snout to vent (SVL); head length (HL), measured diagonally from angle of jaw to tip of snout; head width (HW) between angles of jaws; interorbital distance (IOD); eye diameter (ED); eye length (EL) from anterior to posterior edge; eye to nostril distance (END) from anterior edge of eye to posterior corner of nostril; internares distance (IND) between centers of nostrils; forearm length (FAL) from proximal edge of palmar tubercle to outer edge of flexed elbow; hand length (HAL) from proximal edge of palmar tubercle to tip of third finger; tibia length (TL), distance from knee to distal end of the tibia; foot length (FL) from proximal edge of outer metatarsal tubercle to tip of fourth toe; width of third finger (3FW) at penultimate phalanx just anterior to disk; width of disk of third finger (3FD) at greatest width; width of third toe (3TW) at penultimate phalanx just anterior to disk; width of disk of third toe (3TD) at greatest width; width of fourth toe (4TW) at penultimate phalanx just anterior to disk; width of disk of fourth toe (4TD) at greatest width; body width (BW) at greatest width of body; tympanum diameter (TD), horizontal distance, based on an estimated circular tympanum.

Capitalized colors and color codes (the latter in parentheses) used in the color description of the holotype are those of Smithe (1975–1981). Specimens were deposited in MVUP (Museo de Vertebrados de la Universidad de Panama), MHCH at the Universidad Autónoma de Chiriquí, and SMF. Comparisons between similar species are

based on original descriptions. Geographic coordinates and altitude were taken with a Garmin GPSmap 60CSx given in decimal degrees rounded to the fourth decimal place. Elevations are rounded up to the next tenth. All geo-references were recorded in WGS 1984 datum. The map were created using ArcGIS 10(ESRI). We calculated the preliminary distribution area by drawing the minimum convex polygon around our locality records and measuring the area with the “Area Measurement Tool” of ArcGIS 10.

Advertisement calls were recorded using a Marantz professional (PMD 660) digital recorder and a Shure bg4.1 unidirectional condenser microphone that was arranged between 1.0 to 1.5 m from the calling male. The body temperature of the recorded individual was taken immediately after recording by using an Oakton InfraPro 1 infrared thermometer; environmental temperature and humidity were measured using an Oakton digital thermo-hygrometer. Snout-vent length of each recorded male was taken. Males were recorded using 44 kHz at 16 bit sampling size and files saved in uncompressed .wav format. The spectral and/or temporal parameters of five notes and two note interval per individual were analyzed and the power spectra were calculated in Raven 1.3 (Window: Blackman, DFT: 2048 samples, 3 dB filter bandwidth: 158 Hz; Charif *et al.* 2004). Terminology used in the advertisement call description follows Duellman & Trueb (1994). The obtained images of the oscillogram and the sound spectrogram were enhanced using Adobe Photoshop CS2.

Results

Diasporus igneus sp. nov.

Holotype. MVUP 2301 (original field number MHCH 1327), an adult male (Fig. 3–5) collected on the southeastern slope of Cerro Santiago, Serranía de Tabasará about ca. 4.6 Km from Llano Tugrí (Buabití), capital of the Comarca Ngöbe Buglé, Distrito de Müna, Corregimiento de Peña Blanca, Panama, on March 25, 2009 at 19:35 (8.5079°N, 81.7168°W, 1710 m a.s.l.).

Paratypes. Three adult males from La Nevera, southwestern slope of Cerro Santiago, Serranía de Tabasará, Comarca Ngöbe-Buglé, Distrito de Nole Duima, Corregimiento de Jadeberi, Panama. MHCH 1388 and MHCH 2072 collected by A. Batista April 11, 2009, at 20:42 (8.4996°N, 81.7716°W, 1700 m a.s.l.) and April 12, 2009, at 02:05 (8.4998°N, 81.7719°W, 1700 m a.s.l.), respectively, and SMF 89821 collected by A. Hertz November 11, 2009 (8.4955°N, 81.7672°W, 1820 m a.s.l.).

Diagnosis. *Diasporus igneus* is characterized by the following combination of characters (see Table 1): (1) dorsal skin texture smooth with rounded scattered tubercles, edge of tibia and forearm with a series of low conical tubercles; (2) tympanic membrane not differentiated, tympanic annulus partially visible, $33.7 \pm 4.6\%$ (27.8–38.5) of eye length; (3) snout rounded in dorsal view and in profile; (4) an enlarged and conical supraocular tubercle, cranial crests absent; (5) dentigerous processes of vomers oblique, behind the choanae and posteriorly separated about half of their total length from each other; (6) vocal sac well developed, vocal slits present, no nuptial pads; (7) Finger II longer than Finger I, unguis flap mostly expanded, palmate to truncate, more evident on fingers II–IV, the III finger disk is 2.0 ± 0.2 (1.8–2.2) times wider than distal end of adjacent phalanx (Fig. 5); (8) no fringes or webbing on fingers; (9) a row of rounded ulnar tubercles, most evident in life (Fig. 3 and 5), palmar tubercle rounded, flattened and slightly larger than thenar tubercle; thenar tubercle low and elongate; subarticular tubercles rounded and globular; no supernumerary tubercles, palmar and plantar accessory tubercles small and rounded; (10) heel with two or three small and rounded tubercles; a row of rounded outer tarsal tubercles; (11) no fringes or webbing on toes, unguis flap mostly expanded, more evident on toes II–V, IV disc of toe is $1.8–2.3$ (2.0 ± 0.2) times wider than distal end of adjacent phalanx; (12) plantar tubercle rounded, one to three non-protuberant subarticular tubercles present (one on toes I and II, two on toes III and V, three on toe IV); inner metatarsal tubercle elongated; outer metatarsal tubercles pointed and smaller than inner; tarsal ridge absent; (13) dorsal ground color in life brown with yellow to orange reticulations, groin and axilla red, vocal sac yellow; (14) SVL 26.1 ± 0.5 mm (25.5–26.6); (15) advertisement call composed of a single, amplitude-modulated short note (50.0–100.0 ms) with harmonic structure, and with most energy emitted with the first harmonic (2.2–2.5 kHz).

TABLE 1. Main diagnostic characters and character states for members of the *Diasporus diastema* species group.

Species	SVL (males)	SVL (females)	Dorsal Color	Ventral Color	Groin color	Skin texture	Eyelid tubercle	Tympanum conditions	Ungual flap	Ulnar tubercles
<i>D. anthrax</i>	16.5	18.7	Brown	Brown	Scarlet	Smooth with flat pustules	Absent	Prominent	Expanded	Absent
<i>D. citrinobapheus</i>	17.3–19.7	21.8	Bright yellow	Colorless or with dirty with speckling	Chrome orange	Smooth	Absent	Covered by skin	Spadate	Absent
<i>D. diastema</i>	16.0–21.0	18.0–24.0	Gray to tan	Yellow to dark brown	Yellow to Orange	Smooth with a few scattered tubercles	Absent	Visible ventrally	Palmate to spadate	Absent
<i>D. gutaris</i>	17.2–22.4	21.2–25.4	Pale brown	Cream	Yellow	Smooth	Absent	Distinct	Spadate	Absent
<i>D. hylaeiformis</i>	19.0–22.0	20.0–26.0	Tan, gray to almost black	Yellowish to orange	Yellow to orange	Smooth	Absent	Distinct	Spadate	Absent
<i>D. igneus</i>	25.5–26.6	–	Brownish with yellow to orange reticulations	Yellow	Scarlet	Smooth with scattered tubercles	Present	Partially visible	Expanded	Present
<i>D. quidditus</i>	10.9–14.8	13.2–16.9	Brown	Brown	Brown	Low warts scattered	Absent	Upper edge concealed by supratympanic fold	papillate	Absent
<i>D. tigrillo</i>	16.0–18.0	–	Yellow orange	Yellow	Yellow to orange	Smooth with low pustules	Absent	Indistinct	Spadate	Absent
<i>D. tinker</i>	15.2–20.3	19.0–21.8	Brown	Gray	Brown to orange	Smooth	Absent	Upper edge concealed by supratympanic fold	Papillate	Absent
<i>D. ventrimaculatus</i>	20.2 – 23.5	23.8–24.7	Red to pink	Red to pink	Red or beige	Aerolate	Absent	Distinct	Spadate	Absent
<i>D. vocator</i>	14.0–16.0	16.5–18.0	Gray	Pigmented with dark mottling and light areas	Brown	Shagreen	Absent	Distinct and pigmented	Lanceolate	Absent

Similar species. *Diasporus igneus* can be distinguished from other species of the group as follows (see Table 1 for more details): from *D. quidditus* (Lynch 2001), *D. tinker* (Lynch 2001) and *D. vocator* (Taylor 1955) by its larger size and palmate to truncate unguinal flap instead of lanceolate to papillate unguinal flap. It differs from *D. diastema* (Cope 1875), *D. tigrillo* (Savage 1997), *D. hylaeformis* (Cope 1875), and *D. ventrimaculatus* (Chavez *et al.* 2009) by its larger body size, by having one to several enlarged supraocular tubercles, by having the outer edge of the tibia and forearm covered with a series of tubercles, and by having the groin and axilla colored in red. It is distinguished from *D. anthrax* (Lynch 2001), *D. citrinobapheus* (Hertz *et al.* 2012) and *D. gularis* (Boulenger 1898) by its larger size, dorsal skin with scattered tubercles, and its color pattern.



FIGURE 3. Holotype (MVUP 2301) of *Diasporus igneus* from Llano Tugr .

Description of the holotype. An adult male, with slender body; smooth dorsal skin with low widely spaced pustules, venter coarsely areolate, discoidal fold not evident; one enlarged supraocular tubercle, edge of tibia and forearm with a series of tubercles; eye slightly longer than snout; ratio SL/ED 77%; tympanum of moderate size, ratio TD/ED 38%; tympanum indistinguishable, annulus tympanicus partially visible through skin anteriorly and ventrally, positioned closely behind orbit and lower jaw; head slightly wider than long, greatest head width between angles of jaw 38% of SVL; snout rounded from above and in profile; nares situated near tip of snout and slightly dorsolaterally directed, barely visible in front view, also visible dorsally but not ventrally; canthus rostralis rounded; loreal region feebly concave; dentigerous processes of vomer 1.5 mm of length, and clearly visible, posterior to choana in an oblique outline, each with seven teeth; vocal slits present; tongue length 5.4 mm and 0.4 of width, first half attached to floor of mouth; hands moderate in size, 29% of SVL; relative lengths of adpressed fingers I<II<IV<III; finger IV slightly longer than II, finger II reaching the disk on finger IV when adpressed; finger III disk 1.8 times wider than distal end of adjacent phalanx; palmar tubercle rounded, flattened and slightly larger than thenar tubercle; thenar tubercle low and elongate; subarticular tubercles rounded and globular; no supernumerary tubercles; palmar and plantar accessory tubercles small and rounded; no nuptial pads; no fringes on fingers; hind limbs of moderate lengths, TL 44% of SVL; relative lengths of adpressed toes I<II<III<V<IV; when adpressed, tip of toe I reaches to tubercle of toe II; disc of toe IV moderately expanded, 1.8 times wider than distal end of adjacent phalanx; no fringes on toes; one to three nonprotuberant subarticular tubercles present (one each on toes I and II, two on toes III and V, three on toes IV); inner metatarsal tubercle elongated; outer metatarsal tubercles pointed and smaller than inner; tarsal ridge absent; hands and feet without webbing; finger and toe disks moderately expanded; unguinal flap expanded, palmate; pads broadened and globular in profile (Fig. 3–5).

Coloration of holotype in life. Holotype (MVUP 2301) (Fig. 3) recorded as follows: iris Yellow Ocher (123) with a longitudinal Army Brown (219B) bar in the middle; dorsal ground color Verona Brown (223B), suffused with Clay Color (123D) and Burnt Orange (116); interorbital region with a Burnt Orange (116) line; groin and axilla immaculate Scarlet (14); posterior thigh surface Scarlet (14) suffused with Raw Umber (23), and with Buff (24) bars; venter immaculate Olive Yellow (52) suffused with Scarlet (14); vocal sac immaculate Orange Yellow (18).



FIGURE 4. Ventral and dorsal view of the holotype of *Diasporus igneus* (MVUP 2301).

Coloration in preservative (including paratypes, Fig. 4–5). Dorsal ground color Buff (124), with reticulations Dark Brownish Olive (129), groin Warm Buff (118), vocal sac Trogon Yellow (153), ventral surface Chamois (123D) pointed with Sepia (119).

Measurements of holotype (mm). SVL 25.8; HL 8.2; HW 9.7; IOD 3.2; ED 3.3; TD 1.3; FL 11.6; TL 11.3; HAN 7.5; 3FW 0.7; 3FD 1.3; 3TW 0.6; 3TD 1.3; 4TW 0.8; 4TD 1.4; BW 13.8 (see table 2).

Vocalization. The vocalizations produced by the holotype (environmental temperature = 16.9 °C; humidity 78%; 19:30) and two other males (MHCH 1388, environmental temperature = 16.1 °C; humidity 86%; 20:30 and MHCH 2072, environmental temperature = 15.9 °C; humidity 93%; 02:10) were analyzed. The calls consist of single, short, monophasic notes that are reminiscent of a “whistle” (Fig. 6). Note duration is 0.07 ± 0.01 s (0.05–0.10) with an interval between calls of 13.5 ± 3.5 s (9.0–17.5) and a call rate of approximately four calls per minute. The peak frequency band ranges from 2.0 to 2.7 kHz. The fundamental frequency is also the dominant frequency, at 2.4 ± 0.08 kHz (2.2–2.5), followed by five main harmonic components at 4.6 ± 0.2 kHz (4.5–5.0), 6.8 ± 0.4 kHz (6.2–7.5), 9.3 ± 0.4 kHz (8.7–10.1), 11.8 ± 0.5 kHz (10.1–12.1), 13.6 ± 0.6 kHz (12.1–14.6) (Fig. 6), with most energy emitted in the first harmonic, followed by the second.

Natural history. This species is found in the lower-montane rain forest (1699–1815 m a.s.l.) in the western portion of the Serranía de Tabasará. The vegetation predominantly consists of big trees (roughly 30 m in height) covered with moss, bromeliads (*Werauhia* spp. and *Guzmania* spp.), giant ferns (*Cyathea* spp.) and orchids. The holotype was found calling inside a hole filled with dry leaves in a branch about two meters above the ground. The specimen MHCH 1388 was found calling from inside a bromeliad around five and a half meters above ground. The specimen MHCH 2072 was found calling from a moss-covered bark on a branch approximately five meters above the ground. The specimen SMF 89821 was not calling and sat exposed on a leaf about 0.7 m above the ground. Although the holotype and SMF 89821 were found at low heights, most calling individuals were sitting more than four meters above the ground. Calling individuals are well covered and hard to locate (after searching for approximately three hours at La Nevera, A. Batista could not detect a single individual, although he heard several of them calling). One paratype (MHCH 1388) was stimulated to regurgitate the contents of its stomach (technique provided by A. Amézquita), that contained a woodlouse (Isopoda: Oniscidea) of 2.9 mm length and 8.4 mm width.

Etymology. The species epithet *igneus* is the Latin word for fire, and is here used as a noun in apposition. It refers to the reticulated dorsum in contrast to the red coloration in the axilla and groin that is evocative of fire.

TABLE 2. Measurements and morphological proportions for all specimens of *D. igneus*.

Trait	Measurements (mm)	Trait	Proportion (%)
SVL	26.1 0.5 (25.5–26.6)	IND/SVL	9.8 0.2 (9.7–10.0)
TL	11.7 0.5 (11.3–12.4)	TL/SVL	43.5 0.6 (42.8–43.9)
HL	8.5 0.3 (8.2–8.8)	HL/SVL	32.0 0.8 (31.4–32.9)
HW	9.9 0.2 (9.7–10.1)	HW/SVL	37.7 0.2 (37.5–37.8)
IOD	3.3 0.3 (3.0–3.6)	HL/HW	84.9 2.1 (83.1–87.2)
ED	3.5 0.2 (3.3–3.7)	ED/SVL	13.1 0.7 (12.7–13.9)
TD	1.2 0.1 (1.0–1.3)	TD/SVL	4.7 0.2 (4.5–4.9)
SL	2.5 0.2 (2.3–2.7)	SL/SVL	10.0 0.2 (9.8–10.3)
HAL	7.4 0.2 (7.1–7.5)	HAL/SVL	28.3 0.6 (27.8–29.0)
IND	2.4 0.2 (2.1–2.6)	FL/SVL	44.2 0.8 (43.3–44.9)
BW	13.5 1.2 (12.0–14.8)	FAL/SVL	45.5 0.7 (44.7–46.0)
3FW	0.8 0.1 (0.6–0.9)	BW / SVL	53.2 2.4 (50.6–55.4)
3FD	1.5 0.3 (1.2–1.8)	4TD/4TW	203.3 26.4 (177.9–230.7)
4TW	0.7 0.1 (0.6–0.8)	3TD/3TW	203.7 23.7 (188.9–231.0)
4TD	1.5 0.2 (1.2–1.7)	3FD/3FW	201.1 2.0 (183.3–221.0)

Remarks. All in all, the calls of most species of *Diasporus* appear to be very similar to one another to the human ear, and thus it is difficult to distinguish among them. Subjective description of the call types of the species *D. anthrax*, *D. gularis*, *D. quidditus*, *D. tigrillo*, and *D. tinker* have been mentioned (Chavez *et al.* 2009; Ibáñez *et al.* 1999; Lynch 2001; Savage 2002), but there are no data available for the acoustic properties of these species. *Diasporus vocator* from the western Pacific side of Panama (Río Chiriquí Viejo, 200 m a.s.l.) calls at a highest frequency between 4.6 to 4.9 kHz (A. Batista, unpublished data), very different from that of *D. igneus*, which ranges from 2.0 to 2.7 kHz. The call of *D. diastema* from central Panama ranges between 2.8 to 4.0 kHz (Fouquette 1960, Wilczynski & Brenowitz 1988), and appears to be most similar to that of *D. hylaeformis*, which also calls at highest frequency between 2.4 to 3.1 kHz (Chavez *et al.* 2009), rather than to that of *D. igneus*. The call of *D. igneus* is also different to that of *D. citrinobapheus* which call in bouts (8 to 22 calls per bout) at 2.9 kHz (Hertz *et al.* 2012). The call most similar to that of *D. igneus* is that of *D. ventrimaculatus*, which range between 2.5 to 2.6 kHz, but they differ from one another in call rate, 11 calls/min in *D. ventrimaculatus* (Chavez *et al.* 2009) and 4 calls/min in *D. igneus*. Moreover, most species of the genus *Diasporus diastema* call at low elevations, between the ground and the understory (Ibáñez *et al.* 1999, Lynch 2001, Savage 2002), but *D. igneus* call at higher elevations, from the understory to the mid-canopy.

Diasporus igneus has thus far only been encountered on the western and eastern slopes of Cerro Santiago. We suspect it to be also present on the southern and northern slopes. The estimated distribution area, the slopes of Cerro Santiago above 1500 m a.s.l., comprises an area of about 40 km². The whole area previously has been called Cerro Colorado by Myers and Duellman (1982). This poorly investigated area comprises, besides Cerro Santiago, another prominent peak to the west, the Cerro Sagui, and the surrounding parts of the continental divide between them. The discovery of *D. igneus* increases the number of endemic vertebrate species in this region of the Serranía de Tabasará to ten (Myers & Duellman 1982; Köhler *et al.* 2007; Mendelson III *et al.* 2008; Birdlife international 2011, Hertz *et al.* 2012). The potential high levels of endemism in this unprotected part of the central-Panamanian mountain range is a reason important enough to create the first protected area for the mountains of the Comarca Ngöbe-Buglé, especially when considering that between 1992 and 2000 the Comarca Ngöbe-Buglé lost about 21.8% of its forest, which amounts to the highest deforestation rate in Panama (ANAM 2009).



FIGURE 5. Ventral surfaces of right hand and foot of the holotype of *Diasporus igneus* (MVUP 2301).

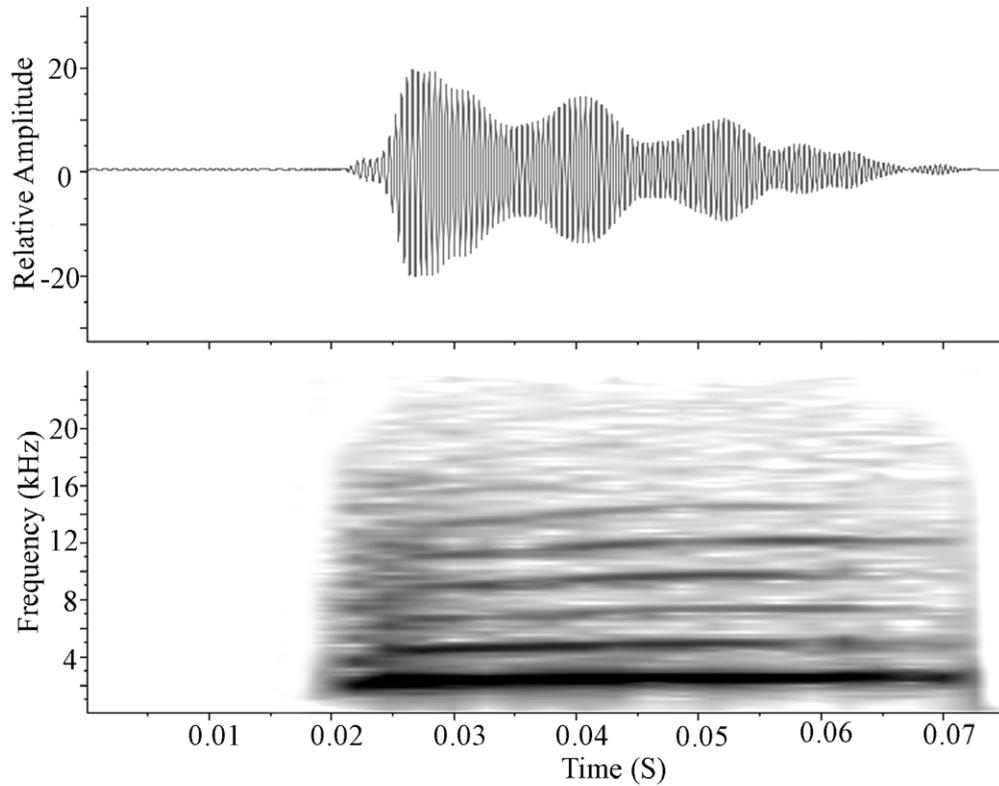


FIGURE 6. Oscillogram (upper) and spectrogram (lower) of the advertisement call of the holotype of *Diasporus igneus* recorded at Llano Tugr  (MVUP 2301).

Acknowledgement

Collecting and exportation permits were provided by A. Salazar, Y. Hidalgo, and J. García, Autoridad Nacional del Ambiente (ANAM), Panama City, Panama. B. E. Sanjur provided valuable assistance with acquisition of these permits. A special thanks goes to the indigenous people of Ngöbe-Buglé, who allowed us to enter their autonomous territory and kindly supported our work logistically. We thank S. Lotzkat for assistance in the field. J. Padial, L. Wilson, A. Crawford, and C. Jaramillo made helpful comments on an early draft of this paper. AB was supported financially by La Universidad de los Andes, Bogota, Colombia, and la Secretaría de Ciencia y Tecnología (SENACYT), Panama. AH was supported financially by the FAZIT-Stiftung.

References

- ANAM. (2009) Informe GEO Panamá (2009) Informe del estado del ambiente. Panamá.
- Auth, L.D. (1994) Checklist and Bibliography of the Amphibians and Reptiles Panama. *Smithsonian Herpetological Information Service*, 98, 1–59.
- BirdLife International (2011) IUCN Red List for birds. Downloaded from <http://www.birdlife.org> on 08/06/2011.
- Boulenger, G.A. (1898) An account of the reptiles and batrachians collected by Mr. F.H. Rosenberg in western Ecuador. *Proceedings of the Zoological Society of London*, 1898, 107–126.
- Charif, R.A., Clark, C.W. & Fristrup, K.M. (2004) Raven 1.3 User's Manual. Cornell Laboratory of Ornithology, Ithaca, NY.
- Chaves, G., García-Rodríguez A., Mora A. & Leal, A. (2009) A new species of dink frog (Anura: Eleutherodactylidae: *Diasporus*) from Cordillera de Talamanca, Costa Rica. *Zootaxa*, 2088, 1–14.
- Cope, E.D. (1875) On the Batrachia and Reptilia of Costa Rica. *Journal of the academy of Natural sciences Philadelphia series*, 2, 93–157.
- Duellman, W.E. & Lehr, E. (2009) *Terrestrial breeding frogs (Strabomantidae) in Peru*. Natur und Tier – Verlag, Naturwissenschaft, Münster, 384 pp.
- Duellman, W. E. & Trueb, L. (1994) *Biology of Amphibians*. The Johns Hopkins University Press, Baltimore and London, 670 pp.
- Fouquette, M.J., Jr. (1960) Call structure in frogs of the family Leptodactylidae. *The Texas Journal of Science*, 12, 201–215.
- Frost, D.R. (2011) *Amphibian Species of the World: an Online Reference. Version 5.5. Electronic Database*, American Museum of Natural History, New York, USA. Available from: <http://research.amnh.org/vz/herpetology/amphibia/> (accessed January 31, 2011).
- Hedges, S.B., Duellman, W.E. & Heinicke, M.P. (2008) New World direct-developing frogs (Anura: Terrarana): Molecular phylogeny, classification, biogeography, and conservation. *Zootaxa*, 1737, 1–182.
- Hertz, A., Lotzkat, S., Stadler, L., Hamad, N., Carrizo, A. & Köhler, G. (2011) Noteworthy records of amphibians from western Panama. *Herpetological Review*, 42, 245–250.
- Hertz, A., Hauenschild, F., Lotzkat, S. & Köhler, G. (2012) A new golden frog species of the genus *Diasporus* (Amphibia, Eleutherodactylidae) from the Cordillera Central, western Panama. *ZooKeys*, 196, 23–46.
- Ibáñez, R., Rand, A.S. & Jaramillo, C.L. (1999) *Los anfibios del Monumento Natural Barro Colorado, Parque Nacional Soberanía y áreas adyacentes/The amphibians of Barro Colorado Nature Monument, Soberanía National Park and adjacent areas*. Editorial Mizrachi & Pujol, S.A., Panama, 187 pp.
- Jaramillo, C.L., Wilson, L.D., Ibáñez, R. & Jaramillo, F. (2010) The herpetofauna of Panama: distribution and conservation status, p. 604–671. In: Wilson, L.D., Townsend J.H., and Johnson, J.D. (Eds.). *Conservation of Mesoamerican Amphibians and Reptiles*. Eagle Mountain Publishing, Eagle Mountain, Utah, pp 604–671.
- Köhler, G. (2011) *Amphibians of Central America*. Herpeton, Germany, 379 pp.
- Köhler, G., Ponce, M., Sunyer, J. & Batista, A. (2007) Four new species of anoles (genus *Norops*) from the Serranía de Tabasará, west-central Panama (Squamata: Polychrotidae). *Herpetologica*, 63, 375–391.
- Köhler, G., Sunyer, J., Ponce, M. & Batista, A. (2008) Noteworthy records of amphibians and reptiles in Panama (Amphibia: Plethodontidae, Craugastoridae, Hylidae, Reptilia: Plectrohidae). *Senckenbergiana biologica*, 88, 329–333.
- Lotzkat, S., Hertz, A., Stadler, L., Hamad, N., Carrizo, A. & Köhler, G. (2010) Noteworthy records of reptiles from western Panama. *Herpetological Review*, 41, 520–523.
- Lynch, J.D. (2001) Three new rainfrogs of the *Eleutherodactylus diastema* group from Colombia and Panama. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, 25, 287–297.
- Mendelson III, J.R., Savage, J.M., Griffith, E., Ross, H., Kubicki, B. & Gagliardo, R. (2008) A spectacular new gliding species of *Ecnomiohyla* (Anura: Hylidae) from Central Panama. *Journal of Herpetology*, 42, 750–759.
- Myers, C.W. & Duellman, W.E. (1982) A new species of *Hyla* from Cerro Colorado, and other tree frog records and geographic notes from western Panama. *American Museum Novitates*, 2752, 1–32.
- Savage, J.M. (1997) A new species of rainfrog of the *Eleutherodactylus diastema* group from the Alta Talamanca region of Costa Rica. *Amphibia-Reptilia*, 18, 241–247.
- Savage, J.M. (2002) *The Amphibians and Reptiles of Costa Rica: A Herpetofauna between two Continents, between two Seas*. University of Chicago Press, Chicago, 934 pp.
- Savage, J.M., Hollingsworth, B.D., Lips, K. R., & Jaslow, A.P. (2004) A new species of rainfrog (genus *Eleutherodactylus*) from the Serranía de Tabasará, west-central Panama and reanalysis of the *fitzingeri* species group. *Herpetologica*, 60, 519–529.
- Smithe, F.B. (1975–1981) Naturalist's color guide. Part I. Color guide. 182 color swatches. American Museum of Natural History, New York, New York, U.S.A.
- Taylor, E.H. (1955) Addition to the known herpetofauna of Costa Rica. *The University of Kansas Science Bulletin*, 37, 499–757.
- Wilczynski, W. & Brenowitz, E.A. (1988) Acoustic cues mediate inter-male spacing in a neotropical frog. *Animal Behavior*, 36, 1054–1063.